

## PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING  
DOCUMENT TRANSMITTED

From the INTERNATIONAL BUREAU

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Commissioner  
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2011 South Clark Place Room  
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Arlington, VA 22202  
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in its capacity as designated Office

Date of mailing (day/month/year)

07 February 2002 (07.02.02)

International application No.

PCT/EP01/09335

International filing date (day/month/year)

26 July 2001 (26.07.01)

Applicant

ALCATEL et al

The International Bureau transmits herewith the following documents and number thereof:

\_\_\_\_\_ copy(ies) of declaration(s) (Rule 47.1(a-ter))

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

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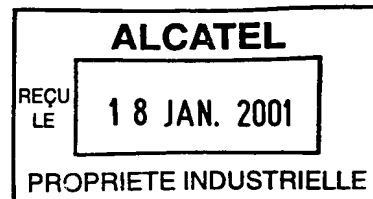
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Département à  
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LA

SAISI  
EN INFORMATIQUE



Datum/Date  
19.01.01

Zeichen/Ref./Réf. 102856LASND/SLL	Anmeldung Nr./Application No./Demande n°/Patent Nr./Patent No./Brevet n°. 00402145.7-2216-
Anmelder/Applicant/Demandeur/Patentinhaber/Proprietor/Titulaire ALCATEL	

## COMMUNICATION

The European Patent Office herewith transmits as an enclosure the European search report for the above-mentioned European patent application.

If applicable, copies of the documents cited in the European search report are attached.

☐ Additional set(s) of copies of the documents cited in the European search report is (are) enclosed as well.

The following specifications given by the applicant have been approved by the Search Division:

☒ abstract

☒ title

☐ The abstract was modified by the Search Division and the definitive text is attached to this communication.

The following figure will be published together with the abstract: 2

## REFUND OF THE SEARCH FEE

If applicable under Article 10 Rules relating to fees, a separate communication from the Receiving Section on the refund of the search fee will be sent later.





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
1 X A	US 5 982 963 A (FEINBERG JACK ET AL) 9 November 1999 (1999-11-09) * column 1, line 9 - line 23 * * column 1, line 45 - line 55 * * column 2, line 8 - line 47 * * column 4, line 48 - column 5, line 33; figures 1,2 * * column 6, line 9 - line 31; figure 4 * * column 8, line 17 - column 9, line 15; figures 10A,10B,10C,10D,10E * ---	1-3 4-7	H04L7/00 H04B10/17
2 X	EP 0 936 773 A (CIT ALCATEL) 18 August 1999 (1999-08-18) * column 1, line 3 - line 41 * * column 1, line 58 - column 2, line 57 * * column 3, line 22 - line 56 * * column 4, line 13 - column 5, line 52; figure 1 * * column 6, line 13 - line 28 * * column 7, line 6 - line 43; figure 4 * ---	1,4-7	
3 X	EP 0 898 391 A (FUJITSU LTD) 24 February 1999 (1999-02-24) * page 2, line 8 - line 19 * * page 3, line 11 - line 24 * * page 6, line 20 - line 25; figures 3,4,13 * -----	1,4	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04B H04L H04J
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12 January 2001	Examiner Roldán Andrade, J
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 40 2145

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-01-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5982963 A	09-11-1999	AU 2086899 A BR 9813627 A EP 1040377 A WO 9931537 A	05-07-1999 21-11-2000 04-10-2000 24-06-1999
EP 0936773 A	18-08-1999	FR 2774832 A JP 11317704 A	13-08-1999 16-11-1999
EP 0898391 A	24-02-1999	JP 11068657 A CN 1209006 A US 6081360 A	09-03-1999 24-02-1999 27-06-2000

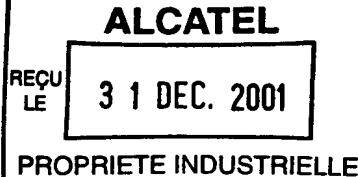
# PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

# PCT

To:

COMPAGNIE FINANCIERE ALCATEL  
Département Propriété Industrielle  
Attn. Lamoureux, Bernard  
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FRANCE



NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL SEARCH REPORT  
OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing  
(day/month/year)

03/01/2002

Applicant's or agent's file reference

102856LASNDV

**FOR FURTHER ACTION**

See paragraphs 1 and 4 below

International application No.

PCT/EP 01/09335

International filing date  
(day/month/year)

26/07/2001

Applicant

ALCATEL

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

**Filing of amendments and statement under Article 19:**

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

**When?** The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

**Where?** Directly to the International Bureau of WIPO  
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1211 Geneva 20, Switzerland  
Fascimile No.: (41-22) 740.14.35

**For more detailed instructions,** see the notes on the accompanying sheet.

identique au  
RR/EP

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau.

If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority



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Authorized officer

Carina Bergström

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>102856LASNDV</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/EP 01/09335</b>	International filing date (day/month/year) <b>26/07/2001</b>	(Earliest) Priority Date (day/month/year) <b>27/07/2000</b>
Applicant <b>ALCATEL</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

2

☐ None of the figures.

## INTERNATIONAL SEARCH REPORT

National Application No

PCT/EP 01/09335

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H04L7/00 H04B10/17

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 H04B H04L H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 982 963 A (FEINBERG JACK ET AL) 9 November 1999 (1999-11-09) column 1, line 9 - line 23 column 1, line 45 - line 55 column 2, line 8 - line 47 column 4, line 48 -column 5, line 33; figures 1,2 column 6, line 9 - line 31; figure 4 column 8, line 17 -column 9, line 15; figures 10A,10B,10C,10D,10E ----- -/--	1-3 4-7

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*G\* document member of the same patent family

Date of the actual completion of the international search

21 December 2001

Date of mailing of the international search report

03/01/2002

Name and mailing address of the ISA

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 01/09335

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 936 773 A (CIT ALCATEL) 18 August 1999 (1999-08-18) column 1, line 3 - line 41 column 1, line 58 -column 2, line 57 column 3, line 22 - line 56 column 4, line 13 -column 5, line 52; figure 1 column 6, line 13 - line 28 column 7, line 6 - line 43; figure 4 -----	1, 4-7
X	EP 0 898 391 A (FUJITSU LTD) 24 February 1999 (1999-02-24) page 2, line 8 - line 19 page 3, line 11 - line 24 page 6, line 20 - line 25; figures 3,4,13 -----	1, 4



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 01/09335

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5982963	A	09-11-1999	AU 2086899 A	05-07-1999
			BR 9813627 A	21-11-2000
			CN 1283278 T	07-02-2001
			EP 1040377 A1	04-10-2000
			TR 200001735 T2	21-11-2000
			WO 9931537 A1	24-06-1999
			US 6330383 B1	11-12-2001
			US 2001021294 A1	13-09-2001
EP 0936773	A	18-08-1999	FR 2774832 A1	13-08-1999
			EP 0936773 A1	18-08-1999
			JP 11317704 A	16-11-1999
EP 0898391	A	24-02-1999	JP 11068657 A	09-03-1999
			CN 1209006 A	24-02-1999
			EP 0898391 A2	24-02-1999
			US 6081360 A	27-06-2000

(19) World Intellectual Property Organization  
International Bureau



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7 February 2002 (07.02.2002)

PCT

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**WO 02/11354 A1**

(51) International Patent Classification<sup>7</sup>: **H04L 7/00**,  
H04B 10/17

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(21) International Application Number: PCT/EP01/09335

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(FR).

(22) International Filing Date: 26 July 2001 (26.07.2001)

(25) Filing Language: English

(81) Designated States (*national*): JP, US.

(26) Publication Language: English

**Declaration under Rule 4.17:**

— of inventorship (Rule 4.17(iv)) for US only

(30) Priority Data:  
00402145.7 27 July 2000 (27.07.2000) EP

**Published:**

— with international search report  
— before the expiration of the time limit for amending the  
claims and to be republished in the event of receipt of  
amendments

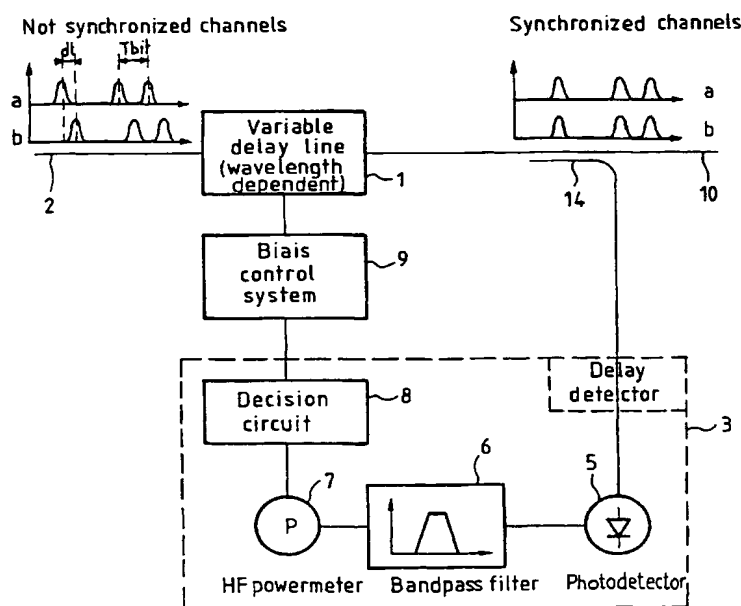
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*For two-letter codes and other abbreviations, refer to the "Guid-  
ance Notes on Codes and Abbreviations" appearing at the begin-  
ning of each regular issue of the PCT Gazette.*

(54) Title: SYNCHRONIZER FOR RZ-WDM SIGNALS AND METHOD FOR SYNCHRONIZATION



(57) Abstract: The invention is related to a synchronizer for more than one optical RZ signal in a wavelength multiplex transmission system comprising at least one variable delay line (1) with an input receiving RZ-WDM optical channels (2), at least one delay controller (3) receiving the RZ-WDM output optical channels (10), the delay controller generating a control signal depending on the power of the RZ-WDM output optical channels (10) and a control circuit (9) to control the at least one delay line (1) in such a way that the optical WDM channels are synchronized.

## Synchronizer for RZ-WDM Signals and method for synchronization

## FIELD OF INVENTION

5

The present invention relates to a synchronizer for RZ (Return to Zero) modulated WDM (wavelength division multiplex) signals.

- 10 The invention also relates to a method to synchronize the RZ-WDM signals with the help of a variable delay line and an electronical feedback loop.

## Background of the Invention

15

- Demand for broadband services (such as high quality data transfer, high definition television and video conferencing) may require telecommunications networks to operate with TBit/s capacities by the first decade of the next century. In order to meet this capacity demand, all-optical or "transparent" networks have been proposed, which networks employ either high speed optical time division multiplexing (OTDM) or wavelength division multiplexing (WDM) to attain the high data-rate. The transparent optical networks rely on optical switching and routing to maintain a transparent path between the source and destination nodes.

25

- In transmission systems, electronic clock recovery circuits are generally used, conventional techniques using electronic filtering in the post detection circuitry. For instance, a high Q electrical filter may be used to extract the clock component in a received data modulation spectrum.
- 30 Within transparent optical network architectures, electronic clock recovery techniques are well know. Using a WDM transmission scheme a large number of independent wavelength channels are transmitted. Each channel is modulated independently from the adjacent channels. The channels are not or only at the transmitters synchronized to each others. The

regeneration function during a transmission line includes a re-modulator. If the channels are not synchronized at the regeneration stage the number of regenerators is equal to the number of channels at each regeneration stage.

5

In return-to-zero (RZ) coding, the frequency spectrum of a coded signal will include a strong peak at the clock frequency. Clock extraction can then be achieved by filtering at the clock frequency and rectifying the result. This involves signal conversion to electronic form. Afterward the clock signals

10 are synchronized by using a phase comparing function. This solution is limited to lower bit rates or increase costs for the requested electronic circuit.

A regeneration and synchronization is known from the US 6,028,898. The signal regenerator comprises a threshold adjustment circuit; a phase

15 adjustment circuit and a re-timing circuit.

Otherwise a complete clock recovery of all RZ-WDM signals is not needed in every regeneration stage of a transmission line.

So the invention is to synchronize the WDM channels in an easy way,

20 without a clock recovery in each channel.

The invention is realized in

A synchronizer for more than one optical RZ signal in a wavelength multiplex transmission system comprising

- 25
- at least one variable delay line (1) with an input receiving RZ-WDM optical channels (2)
  - at least one delay controller (3) receiving the RZ-WDM output optical channels (10)
  - the delay controller generating a control signal depending on the
- 30
- power of the RZ-WDM output optical channels (10) and
  - a control circuit (9) to control the at least one delay line (1) in such a way that the optical WDM channels are synchronized.

The invention comprises also a method for synchronization of RZ-WDM optical signals realized by the steps:

- Separating two channels from the WDM multiplex
- Synchronizing them by
- 5 • Analyzing the power of the two channels
- Generating a control signal for the variable delay line
- Controlling the delay line
- And feeding the resulting synchronized signals back to the next subset of channels so that the synchronized channels are one of the
- 10 two channels of the subset.

#### BRIEF DESCRIPTION OF THE DRAWINGS

A synchronizer will now be described as an example of an embodiment of  
15 the present invention, with reference to the accompanying drawings, in which:

FIG. 1 shows channel power over time

20 FIG. 2 shows a principle structure of the synchronizer

FIG. 3 shows a first embodiment of the synchronizer

FIG. 4 shows a second embodiment of the synchronizer.

25 Fig. 1 shows the function of the resulting power of two WDM channels over a certain delay DT.

To understand the dependence of this function we consider two WDM channels modulated in RZ Signals. This optical RZ-WDM channels are named a and b. The two channels are shifted in time by a time period of  
30 DT measured in Tbit. The modulation rate for this two channels is (1/Tbit) bit/s. With this modulation scheme the two channels a and b both have a

component at  $(1/T_{\text{bit}})$  Hz in their electrical spectrum of power  $P_a$  and  $P_b$ . If the channels a and b are simultaneously detected in a photo detector it can be shown that the power of the component at the frequency  $(1/T_{\text{bit}})$  Hz in the electrical spectra of the optical sum of two incoherent channels follows  
 5 the function:

$$P = \sqrt{(P_a - P_b)^2 + 4P_aP_b \cdot \cos^2\left(\frac{\pi \cdot DT}{T_{\text{bit}}}\right)}$$

If  $P_a = P_b$  the relation is:

10

$$P = 2P_a \left| \cos\left(\frac{\pi \cdot DT}{T_{\text{bit}}}\right) \right|$$

It can be seen that the power  $P$  of the electrical component at frequency  $(1/T_{\text{bit}})$  Hz of the optical sum of the two channels is maximal when the  
 15 pulsed of both channels are synchronized and that  $P$  is minimal when the pulsed of both channels are out of synchronization.

Fig. 2 shows in a schematic way the synchronizer for two optical channels a  
 20 and b. The optical RZ-WDM channels 2 are connected with a first port of a variable delay line 1. The output of the a variable delay line 1 is connected to a transmission line for the synchronized RZ-WDM channels 10. A tap 14 splits optical power and is connected to a delay detector 3. The delay detector 3 is attached to a control system 9 and this control system 9 is  
 25 attached to a second input port of the variable delay line 1. The delay detector 3 consists of a photo detector 5 connected to the input and the tap 14. The photo detector is linked to a band pass filter 6 which is linked to a HF-powermeter 7. The powermeter 7 is attached to a decision circuit 8 and the output connected to the control system 9.

30

The input RZ WDM channels 2 are not synchronized The shift between the two wavelength channels is  $DT$ . The distance between the digital signals for example the signals "1" in the figure is  $T_{\text{bit}}$ . This signals are fed to the

variable delay line. What is need is a control signal to initiate the active shift of one channel compared to the other. At the tap 14 a part of the optical signal, that is not influenced by the delay line in the start of the procedure, is taken to feed the delay detector. Herein the photo detector receives the  
5 optical signal changing it in an electrical broadband signal. This electrical signal is then filtered by a band pass filter centered around the data clock frequency to delete side band and noise signals. The filtered signal is analyzed by a HF power meter.

- 10 This power meter (it could be a RF detection diodes) sensitive to the RF clock level converts the HF signal to a DC electrical level compatible with the so-called decision element 8. The decision element could be realized using electronic enslavement based on operational amplifiers circuitry and transforms the received information in a signal compatible with the variable  
15 optical delay line control system 9. A deviation from the maximum RF level is detected in the decision circuit as an error voltage which is lowered using a P.I.D. regulation technique (Proportional, Integral, Derivative) driving the control system.

For this embodiment the variable delay line is wavelength dependent.

- 20 In another embodiment the decision circuit look for the minima of the signals . The signal structure is also flexible.

The optical delay line could be an adjustable air gap electrically controlled  
25 with a step-motor to change the optical path.

Fig. 3 shows an embodiment of the invention for more than 2 channels. The explanation uses three channels without limiting the scope of the invention.

- 30 The input RZ-WDM channels 2 are connected to a circulator 12. The first port of the circulator 12 is connected with a first tap 14a. The tap 14a is also link over a first fiber grating 11a to a first variable delay line 1a. The output of the delay line 1a is over a second tap 14b and a second grating filter 11b connected to a second delay line 1b.

The second delay line is linked to a third grating filter 14c.

Each tap 14a and 14b is attached over a delay detector 3a, 3b and a control circuit 9a, 9b with an input port of a delay line 1a, 1b.

- 5 The fiber gratings 11 are reflecting one wavelength of the WDM scheme. The fiber grating 11c is reflecting  $\lambda_3$ . So in the variable delay line 1b  $\lambda_3$  and  $\lambda_2$  are compared and synchronized. For the two channels are then synchronized the variable delay line 1a shift  $\lambda_3 = \lambda_2$  versus  $\lambda_1$ . The resulting synchronized signal is fed in the circulator 12 and transmitted over  
10 a second port of the circulator 12.

With this embodiment the RZWDM channels are synchronized beginning with channel N. Than channel N and (N-1) are synchronized, than channel N-2 with the synchronized channels N and N-1 and finally the channel 1 is synchronized with the already synchronized channels (2....N).

15

- Another preferred embodiment is shown in figure 4. In this embodiment the circulator 12 is connected over a grating filter 11a with the variable delay line 1a. The tap 14a connects the second port of the circulator to the variable delay line 1a. The link contains an optical filter 13a for  $\lambda_1$  and  $\lambda_2$   
20 the delay detector 3a and the control circuit 9a.

The next stage of the synchronizer with variable delay line 1b is also connected over a tap to the second output line of the circulator 12. This stage contains an optical filter for the wavelengths  $\lambda_2$  and  $\lambda_3$ . So every stage of the synchronizer synchronize two adjacent channels.

- 25 In another embodiment another filter structure for the optical filters is used. The filters filter  $\lambda_1$  and one additional wavelength out of the WDM. This filter design allows a synchronization of each channel with channel 1.

The synchronizer is used in an intensity/phase modulator in a regeneration stage of the transmission line. For this purpose a high quality band pass  
30 filter is used with  $Q > 1000$  to get an efficient clock recovery system and for



exactly driving the modulator. The other channels can be synchronized using a cheaper low quality filter for example with  $Q = 100$ .

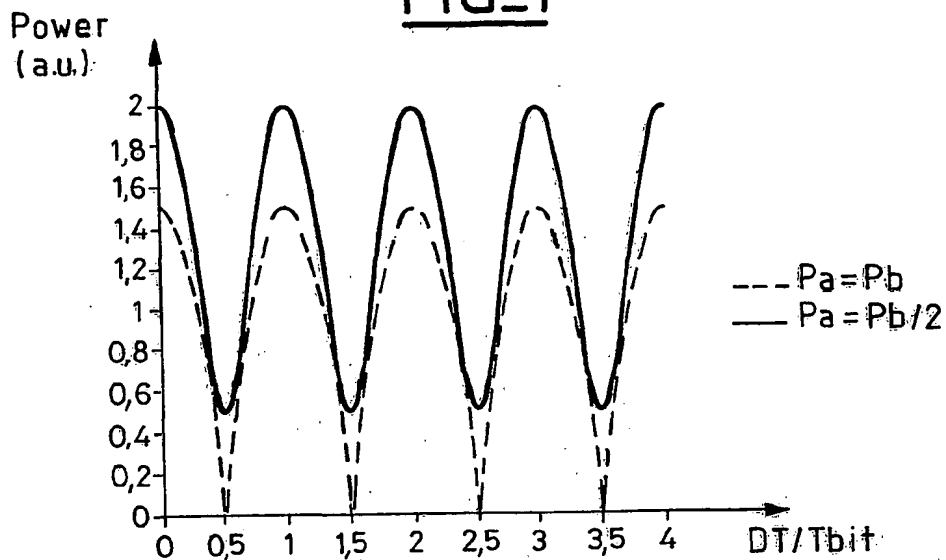
- The whole system is a feed back control loop with a high tolerance versus changes in the optical input power and versus dispersion effects. For the
- 5 synchronizer is adjusting the delays between channels automatically a slight temperature shift on the fiber or a modification of the fiber birefringence and as a result the group velocity of the signal in a channel is leveled out.

## Claims

1. Synchronizer for more than one optical RZ signal in a wavelength multiplex transmission system comprising
  - 5     • at least one variable delay line (1) with an input receiving RZ-WDM optical channels (2)
  - at least one delay controller (3) receiving the RZ-WDM output optical channels (10)
  - the delay controller generating a control signal depending on the HF power of the RZ-WDM output optical channels (10) and
  - 10    • a control circuit (9) to control the at least one delay line (1) in such a way that the optical WDM channels are synchronized.
2. Synchronizer according to claim 1, comprising a variable wavelength dependant delay line (1) for a subset of two RZ-WDM optical channels
  - 15    (1) the channels are separated by fiber grating reflectors (11).
3. Synchronizer according to claim 1, comprising a variable wavelength dependant delay line (1) for a subset of two RZ-WDM optical channels
  - 20    (1) the channels are separated by fiber grating reflectors (11) and optical filters.
4. Method for synchronization of RZ-WDM optical signals realized by the steps:
  - 25    • Separating two channels from the WDM multiplex
  - Synchronizing them by
  - Analyzing the HF power of the two channels
  - Generating a control signal for the variable delay line

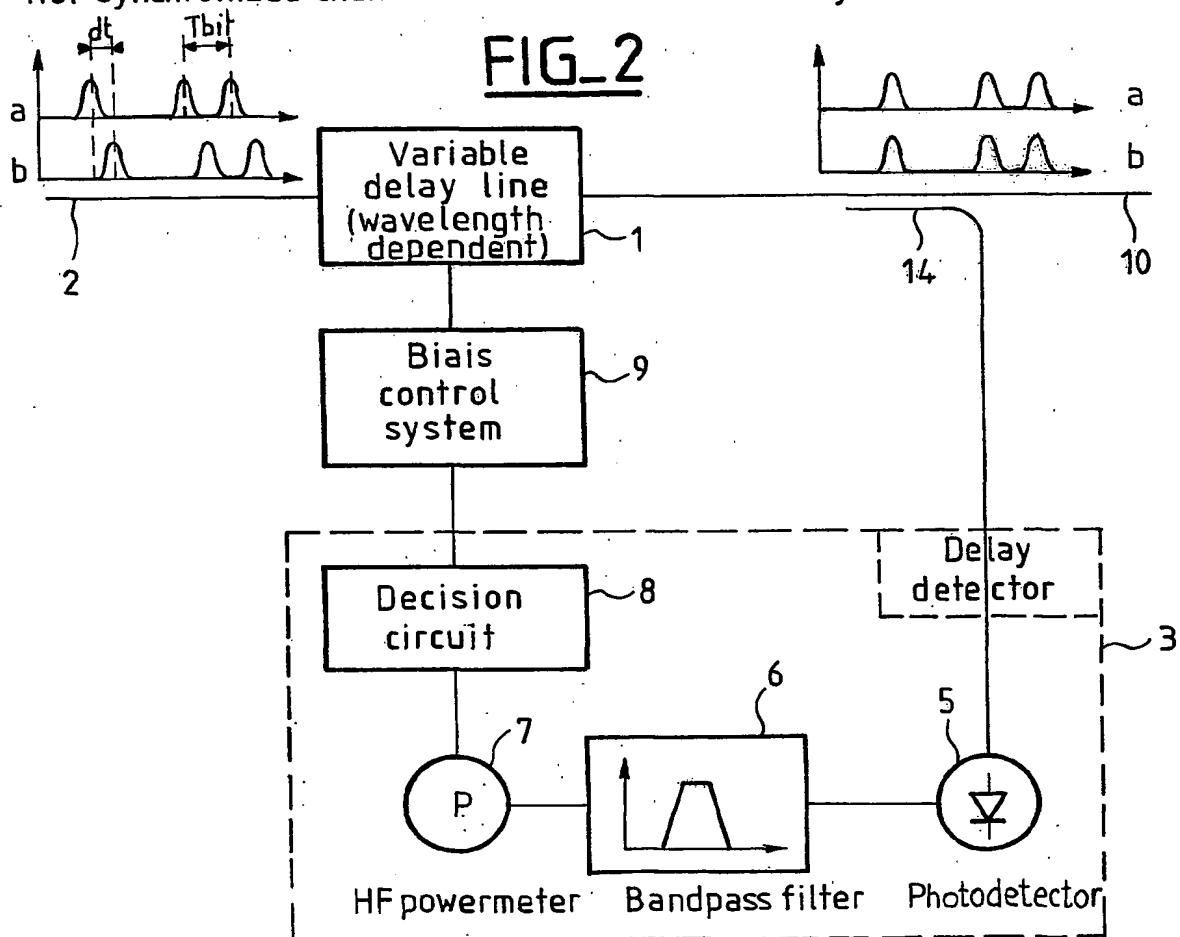
- Controlling the delay line
  - And feeding the resulting synchronized signals back to the next subset of channels so that the synchronized channels are one of the two channels of the subset.
- 5 5. Method for synchronization of RZ-WDM optical signals realized by the steps:
- Separating two channels from the WDM multiplex with optical filters
  - Synchronizing them by
  - Analyzing the HF power of the two channels
- 10 • Generating a control signal for the variable delay line
- Controlling the delay line
  - And feeding the resulting synchronized signals back to the next subset of channels.
6. Method for synchronization of RZ-WDM optical signals according to
- 15 claim 4 in a way that every channel is synchronized with channel 1.
7. Method for synchronization of RZ-WDM optical signals according to claim 4 in a way that the adjacent channels are synchronized.

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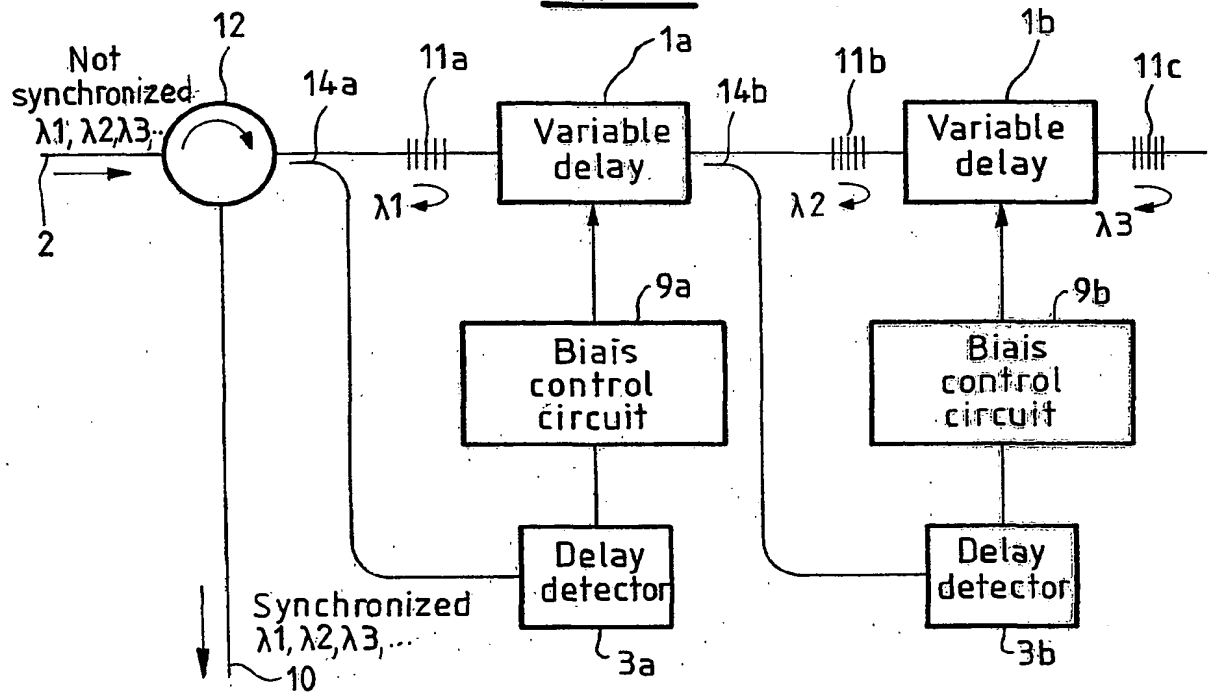
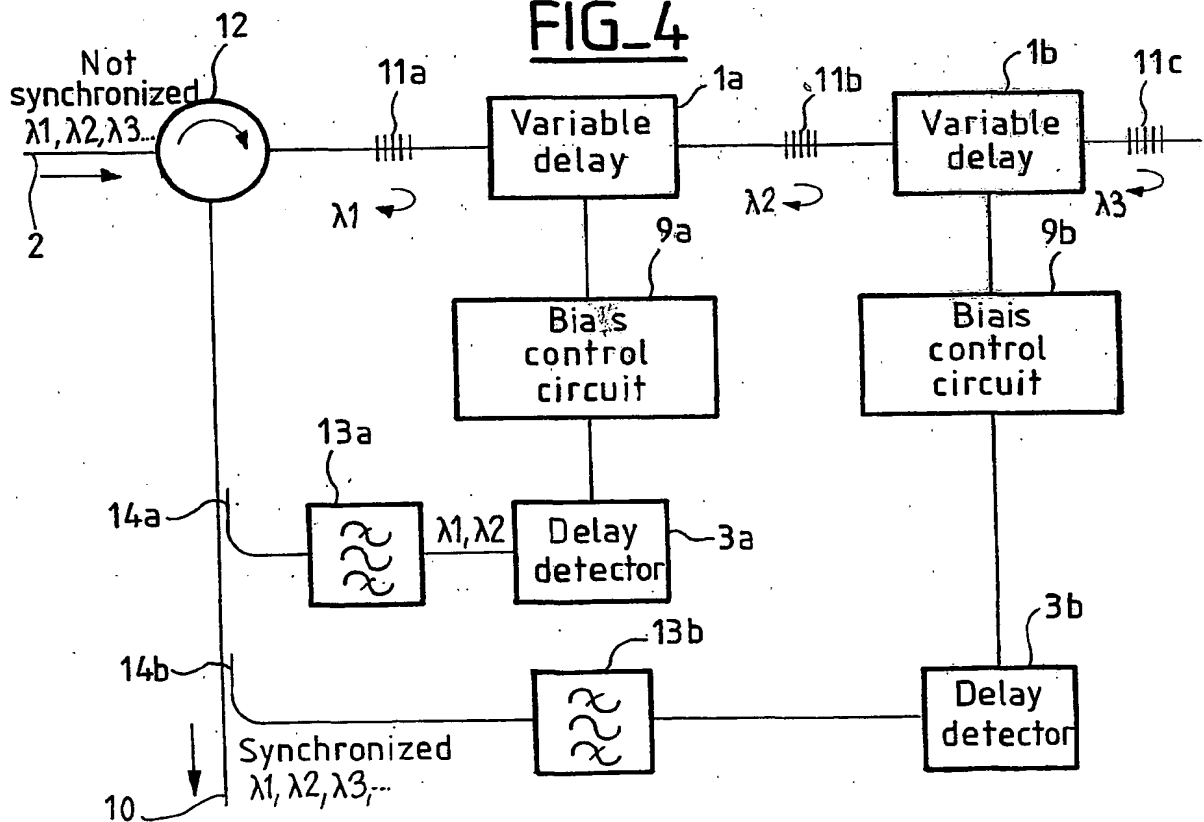
FIG\_1

Not synchronized channels

Synchronized channels

FIG\_2

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FIG\_3FIG\_4

# INTERNATIONAL SEARCH REPORT

In national Application No

PCT/EP 01/09335

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H04L7/00 H04B10/17

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B H04L H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 982 963 A (FEINBERG JACK ET AL) 9 November 1999 (1999-11-09)	1-3
A	column 1, line 9 - line 23 column 1, line 45 - line 55 column 2, line 8 - line 47 column 4, line 48 - column 5, line 33; figures 1,2 column 6, line 9 - line 31; figure 4 column 8, line 17 - column 9, line 15; figures 10A,10B,10C,10D,10E ----- -/--	4-7



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

21 December 2001

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/EP 01/09335

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>EP 0 936 773 A (CIT ALCATEL)  18 August 1999 (1999-08-18)  column 1, line 3 - line 41  column 1, line 58 -column 2, line 57  column 3, line 22 - line 56  column 4, line 13 -column 5, line 52;  figure 1  column 6, line 13 - line 28  column 7, line 6 - line 43; figure 4  ---</p>	1,4-7
X	<p>EP 0 898 391 A (FUJITSU LTD)  24 February 1999 (1999-02-24)  page 2, line 8 - line 19  page 3, line 11 - line 24  page 6, line 20 - line 25; figures 3,4,13  -----</p>	1,4

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